



“The Farmer’s Dilemma”—an Interrupted Case Study for Learning Bacterial Genetics in the Context of the Impact of Microbes on the Organic Food Industry and Biotechnology †

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INTRODUCTION

We teach a large (over 300 students) General Microbiology course that is similar to that offered on many campuses. Students in this one-semester course include majors in Microbiology and other life sciences, but the majority are majors from other disciplines (e.g. Nutrition & Food Science, Psychology, and Kinesiology) and have diverse biology and chemistry backgrounds. As recommended by ASM curriculum guidelines for introductory microbiology, topics in our course include evolution, cell structure and function, metabolic pathways, information flow and genetics, microbial systems, and the impact of microbes (2). Three case studies are used to convey these topics. One-third of the course is devoted to microbial genetics, focusing on information flow and including biotechnology applications. Before constructing this case study, we delivered this information via traditional lectures that included descriptions of real-life applications of bacterial genetics and biotechnology. Despite our best efforts, students were not “getting it.” Their knowledge was noticeably compartmentalized: they were unable to combine information from different topics and use this information to analyze results or make accurate predictions. Many were not able to predict the possible effects of specific mutations in the coding sequence of a gene. Many students thought that a coding sequence from a bacterium could not be translated properly in a eukaryotic cell. They did not appreciate the universality of the central dogma and could not assess when domain-specific or species-specific characteristics were important. From the student perspective, a perceived problem was that we were providing too many examples at a superficial level and that our choices of examples were not engaging. Our solution was to choose one example to serve as an overarching ‘umbrella’ incorporating the genetics and biotechnology topics and linking them in ways that provide opportunities for students to integrate information and concepts.

PROCEDURE

As case studies are well-established pedagogical tools for engaging students (see <http://sciencecasenet.org/>), we developed one to convey concepts in genetics. To find a compelling story line, we tapped into what students found to be intrinsically interesting. Students in the honors section of our General Microbiology course were tasked with generating story lines highlighting genetics. They developed stories that interested them and then pitched their stories to faculty and students. From students’ votes, “The Farmer’s Dilemma” was chosen as the best. We built onto the students’ story to generate our extended, interrupted case study (1).

This case asks students to consider the dilemma of organic farmers who must find an alternative to organic farming when faced with a corn borer infestation (see Table 1 and Appendix 1). Students apply concepts of bacterial genetics in a context that is relevant to the organic food industry and biotechnology.

The Farmer’s Dilemma case addresses the overarching concepts of microbiology related to information flow and genetics, and the impact of microorganisms (2). Specific learning outcomes for each part of the case are found in the Teaching notes (Appendix 2). Our interrupted case format extends over 3 to 4 weeks, as summarized in Appendix 3, Table 1, following an approach that we have described previously (4). This involves presenting an initial introductory story in class, followed by three successive parts, each of which includes new information and specific questions related to that information. Students answer questions online before coming to class, where answers and students’ misconceptions are discussed.

CONCLUSION

The Farmer’s Dilemma case provides a framework for teaching the bacterial genetics and biotechnology module of our large-enrollment General Microbiology course. Five different course instructors have used this case as a teaching tool for ten semesters. In the Teaching notes (Appendix 2), we provide examples of discussion questions and samples of online student responses. We also provide examples of clicker questions that faculty generated for use in class to

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TABLE I.
Case synopsis.

Students assume the role of a team of microbiologists who are experts in topics of biotechnology with an emphasis in the design and use of transgenic corn. The stakeholders in the case are two organic corn farmers: Billy and Thelma. They are struggling with corn borer infestation of their crops and are considering planting BT corn. Billy and Thelma turn to their local farming community for support. The Oakdale community in turn hires a set of scientific consultants (the students take on this role) to educate the group. The farmers ask detailed questions about the technology and the students must respond with answers that are appropriate for an audience of non-scientists. The ASM Academy Report served as a good resource for this case (3).

target common student misconceptions revealed in reading their online responses. The consensus of faculty is that this case is an effective tool in that it has enhanced students' ability to understand, integrate, and apply targeted genetics concepts. In an attempt to quantify the effectiveness of the case, students completed a pre-case and post-case survey (Appendix 3, Table 2). We observed student progress toward mastery of the learning objectives as indicated by an increased percentage of students disagreeing with the statement that, "A protein produced by a transgenic plant is different from that same protein when produced in the cell where the gene (for the protein) is naturally produced" and agreeing with the statement that, "It is possible to express a bacterial gene in a corn plant." Student comments further indicated the positive impact of the case study on student learning (Appendix 3, Table 3). Here is a quote from one student where the authentic character of the case led to a lab job: "I even got an internship in a lab ... doing research on BT corn. Thanks to your class I was able to talk about BT corn very effectively and get the position."

We found this case very useful for engaging students in learning topics of bacterial genetics and bioinformatics. Another benefit is that information gleaned by reading student responses (to case questions and survey questions) has provided us with insights about our students that we have used to design lab exercises and course activities that target the most common misconceptions.

SUPPLEMENTAL MATERIALS

Appendix 1: "The Farmer's Dilemma"

Appendix 2: Teaching notes

Appendix 3: Tables associated with "The Farmer's Dilemma"

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